A NEW SPECIES OF MOSQUITO IN CALIFORNIA, AEDES (OCHLEROTATUS) BICRISTATUS

(DIPTERA, CULICIDAE)[1,2]

By ERNESTINE B. THURMAN[3] AND ERIC C. WINKLER[4]

During routine inspections associated with the mosquito control projects of the Lake County Mosquito Abatement District, third and fourth instar larvae of a new species of mosquito were collected by the junior author near Kelseyville, on February 21, 1950, and forwarded to the Identification-Evaluation Unit of the Bureau of Vector Control for further study. On confirmation by Dr. Alan Stone, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, of the undescribed status of the species, subsequent collections were made in the area surrounding Clear Lake. Between February 21 and April 21, 294 larvae and pupae were collected. From these, 37 males and 92 females were reared, 26 of which were in correlated series. In addition, one male and three females (two biting) were collected in the field. Associated species collected during the study were *Culiseta incidens* (Thomson, 1868), *Aedes varipalpus* (Coquillett, 1902), and *Aedes* sp.

Lake County, with an area of 1,256 square miles, is a region composed of mountains, small valleys, arroyos, and lakes, fitted into the topography of the Coastal Range. The ecological situations represented here are typical of the Upper Sonoran and Transitional Zones of Northern California.

During December, 1949, through early February 1950, Lake County was subjected to short periods of subfreezing temperatures, intermittent rains, and light snows. The snow usually melted within a few hours at lower elevations (1300 ft.), while at Loch Lomond (2600 ft. elevation) 6 inches of snow remained for some 5 days, and an inch of ice was present until the middle of January on some of the shallow pools in flooded meadows. The early spring rains were followed by an unusually dry period. During this time many of the roadside ditches became dry, while some of the meadows, fed by seepage, remained flooded for over 2 months.

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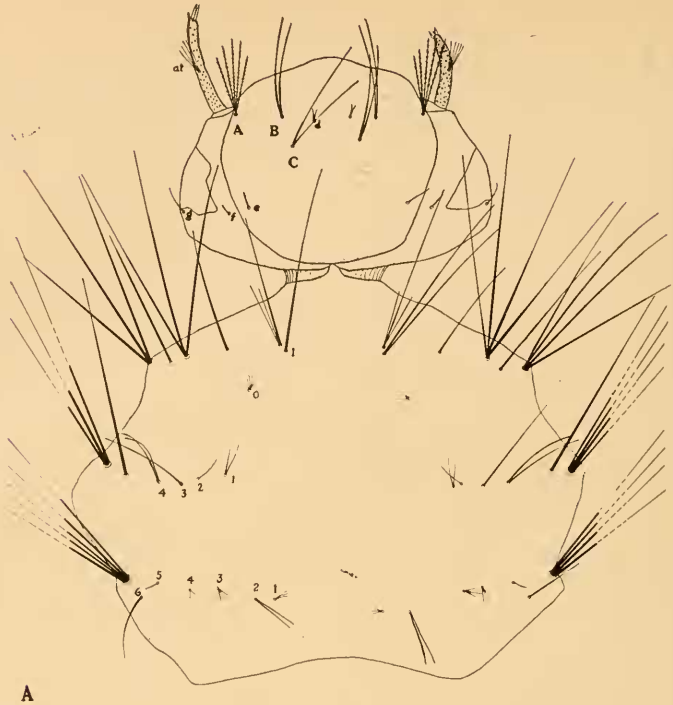
[2]Entire publication costs paid by Bureau of Vector Control, California State Department of Public Health.

[3]Entomologist, P.H.S., Bureau of Vector Control.

[4]Entomologist, Lake County Mosquito Abatement District.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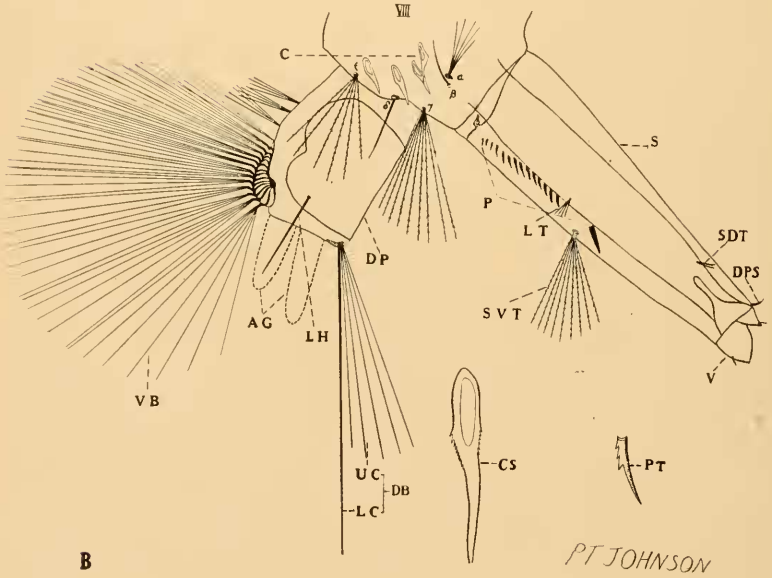
A


VIII
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S
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PT JOHNSON

B

The type locality near Kelseyville, (Township 13 North, Range 9 West, Sections 11 and 12, elevation 1390 ft.) consisted of a grassy roadside ditch and pools in an adjacent flooded meadow. The water depth varied from 3 to 10 inches, and pH readings ranged from 6.7 to 8.0. The emergent vegetation, consisting chiefly of meadow grasses and semi-aquatic weeds, varied from sparse to dense with only a small amount of flotage. In this locality larvae and pupae were collected in full and partial sunlight.

Larvae and pupae were collected by the junior author at 12 sites, all somewhat similar to the type locality, from Blue Lakes, northeast of Clear Lake, south to Loch Lomond, and east to Clearlake Highlands and the junction of Highways No. 53 and No. 20. An additional collection made by John R. Walker of the Bureau of Vector Control from a 5-acre flooded, grassy meadow at Loch Lomond on April 21, included one fourth instar larva, 55 pupae, and two females (biting). These were taken in the shade of ponderosa pines on the west side of the pond, where the water was 4 to 6 inches deep.

Aedes (Ochlerotatus) bicristatus, new species[5]

LARVA (Plate 35). *Head* (fig. A) wider than long. *Antenna* about half as long as head, slightly spiculated; *antennal tuft* (**at**) multiple, inserted near middle, not reaching tip of shaft. *Head hairs: preantennal* (**A**) multiple, barbed; *lower* (**B**) and *upper* (**C**) double; *postclypeal* (**d**) double or triple, minute; *sutural* (**e**), *trans-sutural* (**f**), and *supraorbital* (**g**) single. *Prothoracic hair #1* single or double, twice as long as antenna. *Mesothoracic hairs:* #1 double; #2 single, both inconspicuous; #3 single, long; #4 double, long. *Lateral abdominal hairs* single or double on segments III-VII. *Comb* (C, fig. B) of eighth segment consisting of 4 thorn-shaped scales; individual *scale* (**C–S**) with a central spine longer than the base; minute, lateral spinules near base. Eighth segment hair tufts: *alpha* multiple; *gamma* and *epsilon* multiple, barbed;

[5]Terminology used in description follows that employed by Carpenter, Middlekauff and Chamberlain, 1946.

PLATE 35. AEDES (OCHLEROTATUS) BICRISTATUS, FOURTH INSTAR LARVA

Fig. A, head and thorax; **A**—preantennal tuft, **B**—lower head hair, **C**—upper head hair, **at**—antennal tuft, **d**—postclypeal hair, **e**—sutural hair, **f**—trans-sutural hair, **g**—supraorbital hair. Fig. B, terminal abdominal segments; **VIII**—eighth segment with *alpha*, *beta*, *gamma*, *delta* and *epsilon hairs*, **AG**—anal gills, **C**—comb scales, **CS**—comb scale (enlarged), **DP**—dorsal plate, **DPS**—dorsal preapical spine, **LH**—lateral hair, **LT**—lateral tuft, **P**—pecten teeth, **PT**—pecten tooth (enlarged), **S**—siphon, **SDT**—subdorsal tuft, **SVT**—subventral tuft, **V**—valves, **VB**—ventral brush, **DB**—dorsal brush composed of **LC**—lower caudal and **UC**—upper caudal. Both figures 60×, drawn with the aid of a camera lucida.

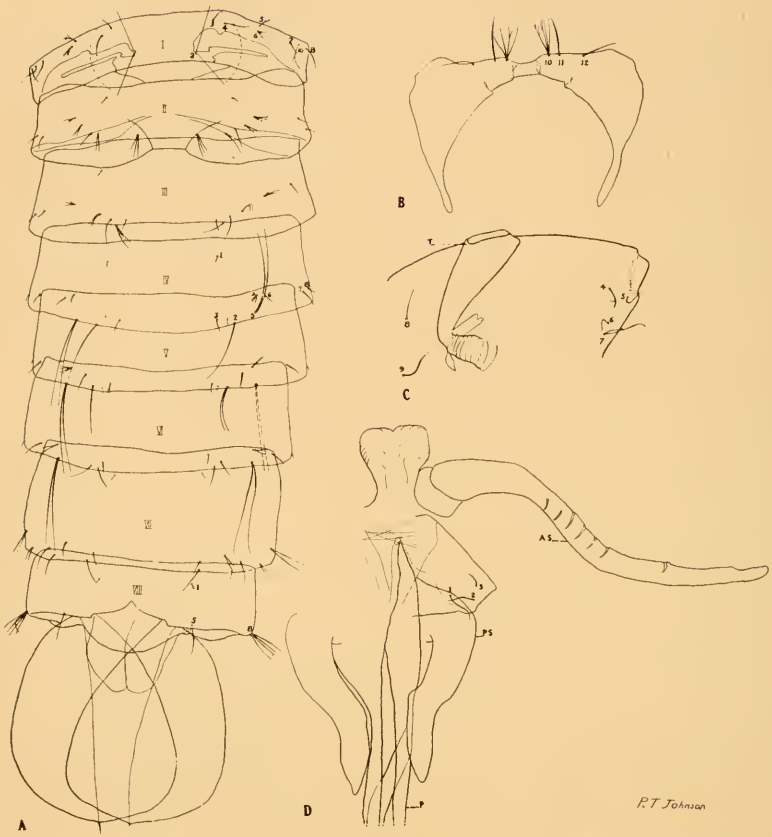


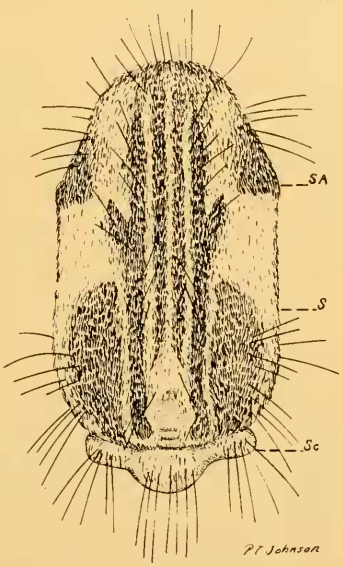
PLATE 36. AEDES (OCHLEROTATUS) BICRISTATUS, PUPA

Fig. A, abdomen and paddles with setae numbered on segments I, IV and VIII following Knight and Chamberlain, 1948. Fig. B, metanotum. Fig. C, dorso-anterior portion of cephalothoracic sheath posterior to head sheath, hairs 4, 5, 6 and 7 are dorsal to antennal sheath, and 8 and 9 posterior to the trumpets, T. Fig. D, head sheath showing antero-ventral hairs 1, 2 and 3, **AS**—antennal sheath, **PS**—palpal sheath, **P**—proboscis sheath. All figures 60×, drawn with the aid of a camera lucida.

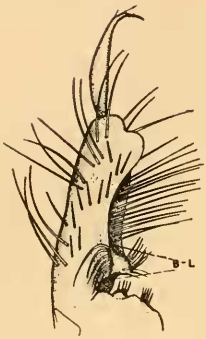
beta and *delta* single. *Siphon* (**S**): length, 3:1; normal *pecten* (**P**) on basal third; individual *tooth* (**P–T**) with 1–3 minute denticles; one heavy, smooth, detached tooth; *siphonal ventral tuft* (**SVT**) multiple, barbed, as long as basal width of siphon, inserted between detached and normal teeth; *lateral tuft* (**LT**) quadruple, fine, almost as long as detached tooth, inserted between and dorsal to detached and normal teeth; *subdorsal tuft* (**SDT**) double, slightly longer than *dorsal preapical spine* (**DPS**), inserted dorso-laterally at preapical fifth. *Anal segment:* longer than wide; *anal dorsal plate* (**DP**) incomplete, covering 4/5 lateral surface, deeply invaginated at ventral, apical third; *lateral hair* (**LH**) single, almost as long as dorsal plate; *anal gills* (**AG**) bluntly pointed, dorsal pair half the length of anal segment, longer than ventral pair; of *dorsal brush* (**DB**), *upper caudal hair* (**UC**) multiple and *lower caudal hair* (**LC**) single, 1½ times as long as upper; *ventral brush* (**VB**) well developed, three short tufts preceding the barred area.

PUPA (*Plate* 36). *Cephalothoracic hairs* (figs. C and D) Nos. 1, 2, 3, 5, 6, 8, and 9 single; Nos. 4 and 7 double; angle of *palpal sheath* (**PS**) rounded. *Metathoracic hairs* (fig. B): No. 10 multiple; Nos. 11 and 12 single. Chaetotaxy of abdominal tergites and paddles as figured (fig. A).

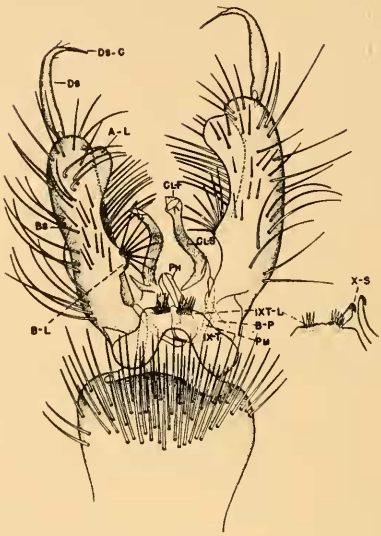
FEMALE. Medium sized, black and white mosquito; abdomen, 5 mm; wing, 4mm. *Proboscis* dark, unbanded, flaked with white scales to tip. *Palpus* dark, white flaked, ¼ as long as proboscis; preapical segment



TEXT FIGURE 1. Dorsal aspect of female mesonotum, *Aedes bicristatus*, **S**-scutum, **SA**-scutal angle, **Sc**-scutellum.


B-L

B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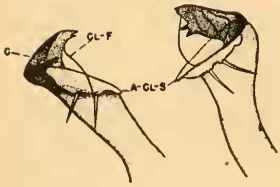
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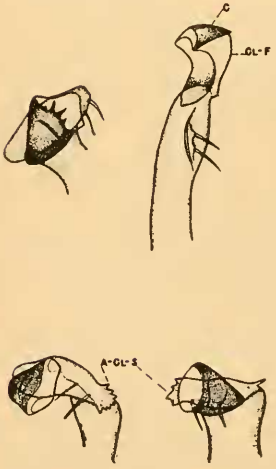
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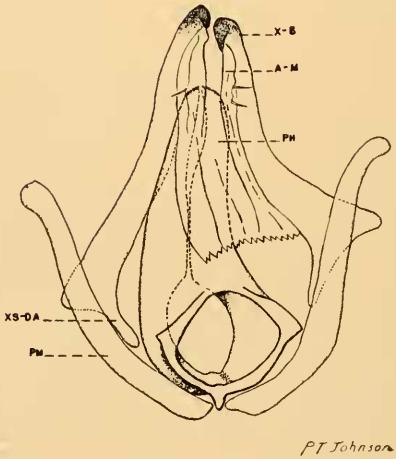
X-S
A-M
PM
XS-DA
PM
P T Johnson

D

⅓ as long as apical segment; apical segment clothed on inner ventral surface with black hairs. *Antenna* dark, first segment clothed with white scales on dorsal surface. *Torus* white scaled on entire surface, integument dark. *Occiput* clothed with whitish, flat scales; stout, black setae dorso-medially projecting forward between the eyes; light setae at vertex; lateral single row of stout dark setae curve over eyes; light, erect, forked scales cover the basal, dorso-medial area with a few dark, erect forked scales intermixed and just posterior to dark simple setae. *Thorax* (Text figure 1): with 4 longitudinal lines of dark flat scales divided by narrow lines of light (tan or whitish) scales from anterior margin; medium dark lines extend to prescutellar patch of light scales; sub-median lines widened posterior to scutal angle, extend to scutellum; *scutum* (**S**) whitish scaled laterally, a narrow line continues sub-medially to scutellum; dark scales form a lateral patch to the *scutal angle* (**SA**) and in the prescutellar space; *scutellum* **(Sc)** with white scales and black bristles; *acrostichal, dorso-central, prescutellar, scutellar,* and *supra-alar bristles* are black and conspicuous; *anterior pronotal lobes* with white appressed scales, a few dark scales, black erect bristles, and ventral bristles light; *propleura* white scaled with many light bristles; *coxa*$_1$ white scaled, few dark scales scattered in middle; *posterior pronotal lobe* clothed with white broad, appressed scales, few black, dorsal bristles, 3 light ventral bristles; *hypostigial spot* conspicuous, white scaled; *spiracular bristles* light; *pre-alar bristles* numerous, light; *sternopleura* clothed with white scales on dorsal area and posterior margin; *sternopleura bristles* numerous and light; *coxa*$_2$ white scaled, few light bristles; *mesepimeron* with white appressed scales, a large patch of fine, light *upper mesepimeral bristles;* 8 light *lower mesepimeral bristles; meron* bare; *metapleura* bare; *metameron* white scaled; *coxa*$_3$ white scaled with a row of light bristles. *Halteres: midhalter* and *capitellum* white scaled. *Wing:* dark, scales narrow; base of *costal vein* and *radius*$_1$ intermixed with white scales to *humeral crossvein;* white scales scatter to apex of *costa;* few light setae on dorsal surface of radius$_1$ near humeral crossvein; three white scales on base of *medial vein; cubital vein* all dark; *anal vein* with white scales at base; fringe all dark, con-

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PLATE 37. AEDES (OCHLEROTATUS) BICRISTATUS, MALE TERMINALIA

Fig. A, internal structures (100×), **A-L**—anal lobe, **B-L**—basal lobe, **Bs**—basistyle, **B-P**—basal plate, **Cl-F**—claspette filament, **Cl-S**—claspette stem, **Ds** — dististyle, **Ds-C** — claw of dististyle, **IX-T** — ninth tergite, **IXT-L**—lobe of ninth tergite, **Ph**—phallosome, **Pm**—paramere, **X-S**—tenth sternite. Figure B, basistyle (264×) showing dorsal and ventral aspects of basal lobe, **B-L.** Fig. C, apical structures of right and left claspettes (430×) mounted at different angles to show sclerotized cap, **C,** with its fingerlike projections on filament of claspette, **Cl-F,** the partial cone-shaped filament, and its line of attachment to the open apex of claspette stem, **A-Cl-S,** with its scalloped edge and two setae. Fig. D, phallosome and related structures, **A-M**—anal membrane, **Ph**—phallosome, **Pm**—paramere, **X-S**—tenth sternite, **XS-DA**—dorsal arm of tenth sternite. All figures drawn with the aid of a camera tacida.

posed of a triple row of short, medium, and long scales; *alula* with one row of dark, oar-shaped, short scales; squama edged with numerous, fine, hair-like light scales; *petiole* shorter than 2nd marginal cell; *mid crossvein* separated from *posterior crossvein* by less distance than length of posterior crossvein. *Leg:* unbanded; *femur* black and white flaked outside, all white inside, dark preapically; *kneespot* white; *tibia* black and white flaked, dark apically; *tarsal segments:* I flaked; II dark; few white scales; III dark, very few white scales; IV and V dark. *Abdominal segments:* I clothed with large, broad, pointed white scales and long light bristles; II-VII dark with broad, white bands on basal third, slightly widened at laterals, with scattered white scales apically on VI and VII; *cerci* dark; *venter* predominantly light scaled.

MALE. Coloration similar to that of female. *Terminalia* (Plate 37): *Dististyle* (**Ds**, fig. A) inserted at apex of basistyle, slightly swollen medially, few setae scattered near apex; *claw of dististyle* (**Ds–C**) tapered to point; *basistyle* (**Bs**) slender, almost three times the basal width, concave and open on inner surface; scales, fine spicules, and short and long setae on basal surface; long setae on apex; median-ventral edge with a dense row of long setae; *apical lobe* (**A-L**) prominent with short setae; *basal lobe* (**B-L**, figs. A and B) large, dorsal surface with 7 or 8 long setae, lobe tapers ventrally, ventral point with a tuft of setae; *tenth sternite* (**X-S**, figs. A and D) with a hook-like point at apex; *dorsal arm* of *tenth sternite* (**XS-DA**) simple; *anal membrane* (**A-M**) with 1 or 2 small setae at apex; *phallosome* (**Ph**) conical, open ventrally, flared at base with lateral and basal projections, apex fringed; *paramere* (**Pm**) simple, slightly knobbed at apex; *claspette* (**Cl-S** and **Cl-F**, figs. A and C) long, slender, cylindrical; *claspette stem* (**Cl-S**) five times the length of the filament, with fine setae from *inner-basal fold* to pre-apex; *apex of stem of claspette* (**A-Cl-S**) expanded, open, scalloped, bearing two setae; *filament of claspette* (**Cl-F**) short, a partial cone, open on the inner aspect, with a sclerotized cap bearing finger-like projections, base of cone attached along outer rim of, and forming a semi-circle at, the apex of the stem; *ninth tergite* (**IX-T**, fig. A) wider than long, base rounded laterally, deeply invaginated medially, narrowed medio-laterally to small *lobes* (**IXT-L**), separated by median-projection narrower than width of a lobe, each lobe bearing 5 or 6 short spines.

Type specimens have been deposited in the U. S. National Museum. Paratypes have been deposited in the collections of the California Academy of Sciences; University of California, Berkeley and Davis; Cornell University; Communicable Disease Center, Atlanta, Ga.; National Institutes of Health, Bethesda, Md.; United States Department of Agriculture, Corvallis, Oregon; Bureau of Vector Control; and the authors.

Few variations of consequence were noted in the terminal structures of the males and the coloration of the females. On

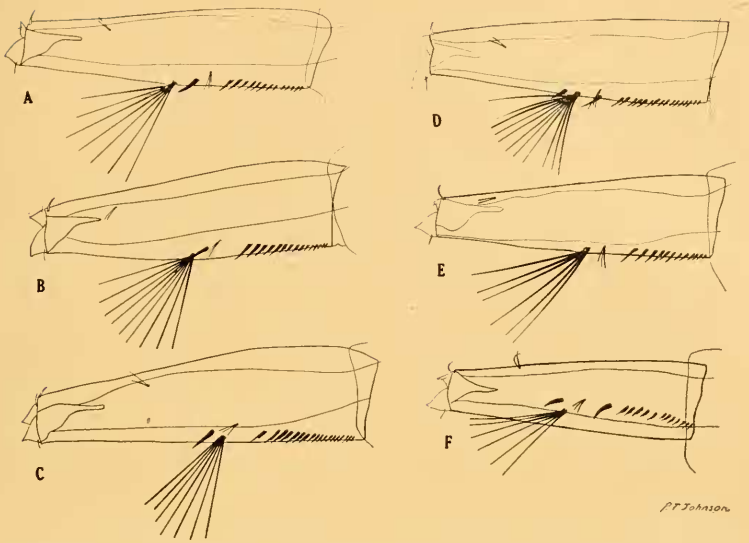


PLATE 38. AEDES (OCHLEROTATUS) BICRISTATUS, VARIATION IN THE NUMBERS OF DETACHED PECTEN TEETH, LENGTH OF SIPHONS, AND POSITIONS OF SIPHONAL TUFTS

Figs. A and B, subventral tuft apical to single detached tooth (specimens #38-4 and #38-6). Fig. C, subventral tuft basal to single detached tooth, siphon 4:1 (specimen #38-7). Fig. D, subventral tuft between two detached teeth (specimen #38-2). Fig. E, subventral tuft adjacent to single detached tooth (left side of specimen #38-3). Fig. F, subventral tuft between two detached teeth, siphon 3:1 (right side of specimen #38-3). All figures 60×, drawn with the aid of a camera lucida.

the thorax the light scales may be drab golden as well as tan or white. In the female the palpi may be ⅕ to ¼ the length of the proboscis. In the study of 139 larvae, with characters of both right and left sides being tabulated, variations were confined within a limited range. Lower and upper head hairs were occasionally barbed, single, double, triple, or combinations of the three with 84 per cent of the lowers and 82 per cent of the uppers being double. In prothoracic hair No. 1, 58 per cent were single; 20 per cent single and double; 21 per cent double; and 1 per cent triple. The number of comb scales ranged from 1 to 5 with 49 per cent having 4 scales on both sides; 31 per cent, 4 and 5 scale combinations; and 11 per cent, 5 scales. Variations in the number of detached pecten teeth were from 0 to 4 with the greatest percentage falling within the category of single on both sides (58 per cent); 16 per cent, double on both sides; and 23 per

cent, single and double combinations. The position of the basal siphonal tuft in relation to the position and number of detached pecten teeth (Plate 38) was noted to be basal, adjacent, apical, and combinations of the three positions, with 42 per cent being basal; 19 per cent, basal and apical; and 15 per cent, apical. In the number of hairs in the lateral siphonal tuft, the range included 0 to 4 with 16 per cent being double; 19 per cent, double and triple; 37 per cent, triple; and 12 per cent, triple and quadruple. The number of hairs in the subdorsal tuft included 0 to 3 with 44 per cent being single; 18 per cent, single and double; and 26 per cent, double. The lateral hair of the anal segment was the most constant character tabulated, 99 per cent being single.

In view of the narrow range of variations noted, it is felt that the species has become stabilized in its evolution and is indigenous to the localities described. Future investigations will probably reveal its presence in other similar localities which are flooded by melted snow or cold water. Three female specimens loaned by Dr. R. M. Bohart, two collected in Glen Ellen, Sonoma County, March 28, 1937 (N. W. Frazier) and the other in the Petrified Forest, Sonoma County, March 16, 1947 (R. M. Bohart), were too rubbed for positive identification; however, it is possible that one or both of the specimens collected by Frazier may be *bicristatus* while the one collected by Bohart may represent an undescribed species. An additional eight females loaned by Dr. C. Don Grant, collected at Woodside, San Mateo County, April 10, 1950, also too rubbed for identification, may possibly be *bicristatus*.

The study of *bicristatus* revealed a definite affinity to *Aedes trichurus* (Dyar, 1904) which occurs in wooded regions of southern Canada, and northern United States from New York west to the Rocky Mountains. Dyar (1904, p. 170) provisionally described the species as a *Culex* on the "unusually hairy air tube of the larva, since it is the only species of the short-tubed group that has more than a single hair tuft." Matheson (1944) lists the larva of *trichurus* as having an incomplete anal plate, detached pecten teeth, siphonal tuft within the pecten, 3 or 4 minute hair tufts above the pecten, and 8 to 10 dorsal hair tufts; and the male claspette as a long, curving cylindrical stem, slightly expanded before the apex; filament very short, stout and bearing a series of parallel, transverse, elevated ridges.

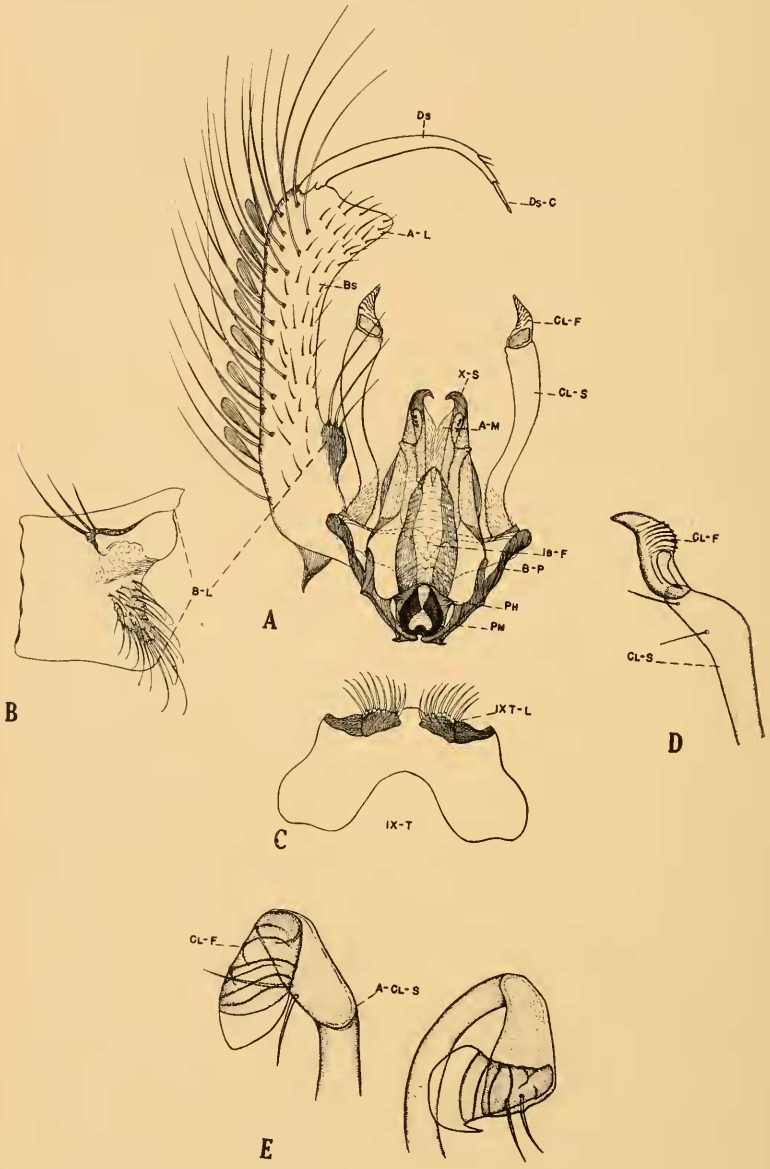
The structures of the male terminals of *trichurus* are presented (Plate 39, figs. A, B, C, and D) in order to demonstrate the points of similarity in the two species and to clarify the figures of the structures as shown by earlier workers. Dyar (1928) and Matheson (1944) have figured the basal

lobe to have both the ventral and dorsal setae on the dorsal surface with an accessory lobe or fold bearing two of the long setae. The basal lobe (fig. B) has 3 heavy setae on the dorsal surface and tapers to a ventral point covered with finer, shorter setae. The tenth sternite (fig. A) terminates in a curved point. The phallosome shows lateral projections at the base, and a fringed apex. The ninth tergite (fig. C) has a deep invagination in the base, slight lateral concavity, and a small apical projection between the lobes which bear 9 to 11 setae. The claspette shows a length proportion of 4 or 5:1 between stem and filament comparable to *bicristatus*. The stem (**Cl-S**, fig. 4) is expanded preapically and the closed apex bears 2 distinct setae. The filament (**Cl-F**, fig. D) is nearer being a complete cone than in *bicristatus*, there being only a small opening on the inner surface near the base. Its sclerotized cap covers the apical portion and has transverse ridges rather than finger-like projections.

Aedes rusticus (Rossi, 1790), a widely distributed species of Europe (Marshall, 1938), is closely allied to these two American species, in that the larva has detached pecten teeth, the basal tuft within the pecten, on the siphon a small lateral tuft and three single dorsal hairs; and the male terminalia possesses a long claspette stem terminating in an open apex with two distinct setae, and a short cap-like filament partially sclerotized and with transverse ridges (Plate 39, fig. E).

Currently *trichurus* and *rusticus* are placed in the subgenus *Ochlerotatus* Lynch Arribalzaga. In 1930 Martini (Edwards, 1932) proposed *Feltianus* as the subgeneric name for *Aedes diversus* (Theobald, 1901) which Edwards (1932) lists as a synonym of *rusticus*. Eight informal groups (A, B, C, D, E, F, G, and H) of the species of *Ochlerotatus* were designated by Edwards (1932), who in some instances suggested names for the groups. Besides *rusticus* and *trichurus*, Group H (*rusticus*-group) includes *Aedes lepidonotus* Edwards, 1920; *A. refiki* Medjid, 1921; *A. stampari* Apfelback, 1929; and *A. subdiversus* Martini, 1926. Of Group H, the authors have had the opportunity to study specimens of only *rusticus* and *trichurus*.

In the large sugenus *Ochlerotatus* composed of many species, 118 listed by Edwards (1932) and 81 listed for the Americas by Vargas (1949), one group, now consisting of 7 species, is known to possess both larval (except *stampari*) and male terminal characters demonstrating definite affinities, and as a group to be distinctly different from all other species in the subgenus and genus. Species other than Group H described in the genus *Aedes* possess only one tuft of hair on the larval siphon and species placed in the subgenus


Ds
Ds-C
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D
IXT-L
IX-T
C
CL-F
A-CL-S
E

Ochlerotatus have claspettes of the male terminalia of varying forms with the filament described as being simple, lanceolate, blade-like, sickle-shaped, expanded at the base, middle, or apex, bearing retrorse teeth, finger-like projections, blunt or pointed recurving apices, and being almost as long as, or in the majority of the species, longer than the stem. From this brief study it is evident that a comprehensive re-evaluation of the basic systematic status of the genus *Aedes* Meigen is needed with emphasis on the subgeneric groupings.

It is the consensus of some eminent workers who have studied *bicristatus* individually or as small groups (Dr. Alan Stone, United States National Museum; Dr. E. S. Ross, California Academy of Sciences; Harry D. Pratt, Scientist, and Deed C. Thurman, Jr., S. A. San., Communicable Disease Center, Public Health Service, Federal Security Agency; Mr. W. H. W. Komp, National Institutes of Health; Drs. Stanley B. Freeborn, Robert L. Usinger, E. Gorton Linsley, and Richard M. Bohart of the University of California; and Mr. Richard F. Peters, Bureau of Vector Control), and the authors that *bicristatus* may be placed in Edwards' Group II of the subgenus *Ochlerotatus* with the status of the group to remain unchanged until the time when a complete re-evaluation of the genus *Aedes* may be accomplished by an energetic and capable worker.

Summary

The larva, pupa, female, and the male terminalia of *Aedes* (*Ochlerotatus*) *bicristatus*, new species, are described and figured. A total of 294 larvae and pupae, one male, and three females (two biting) was collected in Lake County between February 21 and April 21, 1950, from meadow pools and roadside ditches flooded by early spring rains following light

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Plate 39. Aedes (Ochlerotatus) trichurus and Aedes (Ochlerotatus) rusticus, male terminalia

Figs. A-D, *trichurus*, Fig. E, *rusticus*. Fig. A, diagrammatic sketch of internal structures, **A-L**—anal lobe, **A-M**—anal membrane, **B-L**—basal lobe, **Bs**—basistyle, **B-P**—basal plate, **Cl-F**—claspette filament, **Cl-S**—stem of claspette, **Ds**—dististyle, **Ds-C**—claw of dististyle, **IB-F**—inner basal fold, **Ph**—phallosome, **Pm**—paramere, **X-S**—tenth sternite. Fig. B, basistyle enlarged showing dorsal and ventral aspects of basal lobe, **B-L**. Fig. C, ninth tergite, **IX-T**, and lobes of ninth tergite, **IXT-L**, enlarged. Fig. D, apical structures of claspette enlarged to show sclerotized transverse ridges on the cone-shaped filament of claspette, **Cl-F**, and two setae on stem of claspette, **Cl-S**. Fig. E, apical structures of *rusticus* enlarged to show sclerotized area with transverse ridges on filament of claspette, **Cl-F**, and the apex of stem of claspette, **A-Cl-S**, with its two distinct setae. Figures D and E 430×, drawn with the aid of a camera lucida.

snows and freezing weather. A total of 37 males and 92 females was reared, 26 of which were in correlated series. A brief discussion is presented of the definite affinities noted in the characters of the larva and male terminalia of the species to those of the species listed in Group H (*rusticus*-group) by Edwards (1932), and the sharp differences in the morphological characters of the group from those described for other species of the subgenus *Ochlerotatus*, genus *Aedes*. The recommendation is made that a diligent and capable worker undertake a comprehensive study to re-evaluate the systematic position of Group H in relation to the subgenera of *Aedes* and the genera of Culicidae.

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